Delivering clean cold chain

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The need for cold chain

In developing markets, up to 50% of food can be lost post-harvest primarily because of lack of cold chain

• More than 75% of the world’s 1 billion people living in extreme poverty reside in rural areas, primarily dependent on agricultural production. We cannot address rural poverty without cold chains connecting farmers to market.

• 800M people globally are malnourished. Malnutrition is in fact the largest single contributor to disease in the world, according to the UN’s Standing Committee on Nutrition. More children die each year from malnutrition than from AIDS, malaria and tuberculosis combined.

• The consequences of food loss are far beyond hunger, farmer poverty and inflated food prices. Post-harvest food loss
  • occupies a land area almost twice the size of Australia,
  • consumes 250kms of water per year, three times the volume of Lake Geneva;
  • emits 3.3 billion tonnes of CO2, making it the third biggest emitter after the US and China.

Cold chains vaccines - The World Health Organization estimates 25% of liquid vaccines are wasted each year primarily because of broken cold chains. An estimated 1.5 million people die each year from vaccine preventable diseases.
Cold Chain

90% of food loss in developing countries is caused by losses in the supply chain

Cold Chain

An integrated, seamless and resilient network of refrigerated and temperature-controlled pack houses, cold storage, distribution hubs and vehicles used to maintain the safety, quality and quantity of food, while moving it swiftly from farm gate to consumption point.

It should enhance economic wealth, cash flow and security for farmers and improve food quality, safety and value to the customer; and achieve this sustainably with minimum environmental and natural resource impact.

India – an example

Upwards of 40% of perishable food is lost between the farm gate and markets in India. To double farm income by 2022, the Government of India has set out a 7-point strategy. Developing “cold chain” is one of the key measures under “Operation Green”. There is an estimated shortfall of 96% pack-houses, 85% refrigeration vehicles, 10% bulk-storage and 91% ripening chambers in this space.
Cold Chain

Cold chain relies on diesel both in transport and off-grid applications

As an example a transport refrigeration unit:

• consumes up to 20% of a refrigerated vehicle’s diesel
• can emit up to 6x as much NOx and 29x as much PM of Euro VI engine
• produces significant amounts of CO\(_2\)

The number of transport refrigeration units on road by 2050 (11M) could emit the same pollution as 400M diesel cars.

Key to delivery

• To cope with demand growth in an effective, efficient sustainable way, all the integrated elements of the cold chain, from farmer to point of consumption, need to be designed into a seamless system; all using natural or ultra-low GWP refrigerants and harnessing renewable, free and waste energy sources most efficiently;

• Cold chains are bespoke to a variety of factors including the produce (horticulture, dairy, fish, etc), volume, distance, climate, economics, etc; one size does not fit all;

• Work to date has identified that material barriers to market uptake exist through such issues as financial inaccessibility, lack of awareness and absence of local capacity to design and deploy cooling facilities that fit with the local context;
Cold Economy – doing cold smarter

As we migrate from fossil fuels to renewables, we need a whole system approach to develop new, efficient strategies to include cooling.

- We need to cost-effectively smooth intermittent renewable generation and unreliable grid supply as well as provide zero-emission temperature controlled transport.

- Strategies will need to recognise the portfolio of available resources including free and waste cold and heat, incorporate technology, data connectivity and energy management and consider the role of energy storage as well as the specification of resource pooling protocols.

- And we have to design of the novel finance and business models (cold as a service) required to create an economically sustainable, end-to-end system.

The question is ‘what is the service we require, and backcasting how can we provide it in the least damaging way’, rather than ‘how much electricity do I need to generate?’
**Cold Economy – An open-access methodology**

Comprehensive, open-access but flexible clean cooling methodologies are required so that communities can design ‘fit for market’ – including ‘fit for energy source’ - and ‘fit for finance’ cooling.

**Making cold**
Harness waste/unused resources e.g.: ‘wrong time’ renewable energy (e.g. wind), waste cold (e.g. LNG) ambient heat & cold (e.g. ground source)

**Storing cold**
Thermal energy storage to warehouse

**Moving cold**
New energy vectors and material to shift cold

**Using cold**
Reduce cold loads
Increase efficiency and reduce GWP of conventional technologies
New technologies to harness new stores and vectors

**Managing cold**
Monitoring, controls and management

**Financing Cold**
How do we charge and pay for cold
1. Open-access methodology and model

Given the scale and urgency of the problem and the range of product sectors, distances, climates (including humidity), energy sources, markets and economic models, uncoordinated experimental technology deployments are not appropriate for replicability and scaling.

“fit for market” & “fit for finance”

An open-access model and methodology for communities to

- assess their end to end cold chain needs (and minimise demand);
- identify energy resources, including free and waste thermal sources (hot and cold);
- make a set of choices about which cooling technologies are most effective to meet their needs and energy mix
  - How to balance the needs for cooling with the resources available?
  - How to deliver resilience?
  - Spatial & temporal balancing of dynamic needs
- design finance and business models to share value and create an economically sustainable end to end system;
- define the funding requirements and financial (+social and environmental) benefits in such a way as to be in the best position to secure financing/business engagement.
2. In-country Living Labs and Centres of demonstration

Potential solutions are on the point of commercialisation, but it is not enough simply to demonstrate that each of the new clean cold technologies works individually. Instead we need to test, evaluate and demonstrate cold systems working in a community or cold chain as a *chain connecting farm to consumption centre*, rather than as a series of isolated facilities.

We also need to demonstrate affordable business models – servisation.

*And show the economic value back to the farmer*

The Living Labs will in the first instance test and prove the model and methodology.

They will demonstrate the total cold chain, not simply one technology nor one element (be it first mile, last mile, warehousing or transport) and also the business, governance and funding models proposed,

Combined with the model and methodology, the Living Labs can be Centres of Excellence to provide launch-pads for accelerated deployment with a *robust methodology to support different community needs*, proper demonstration of value gain as well as understanding of risk.

- They will provide the essential knowledge transfer, capacity building and training - including maintenance to marketing – to create local jobs, skills and livelihoods in the heart of the communities.
Feeding the planet is not just the business of farmers. Refrigerated logistics is critical to managing our food resources, expanding market frontiers and reducing food loss. At the same time we also need to reduce the impact of our logistics on our environment, and that requires international collaboration. We need innovation today, to develop the sustainable cold chain of tomorrow.

Pawanexh Kohli, CEO of the National Centre for Cold Chain Development, (GOI taskforce on cold chain)

In Summary

Sustainable, affordable and resilient cold chain is key to
• underpin health
• Enhance economic wealth and security for farmers
• Achieve nutritional security and deliver safe food to the wider population

and ensure that the massive growth in demand for cooling is managed within the constraints of natural resources, local economies and underpins, rather than undermines
✓ CO2, Climate Change and pollution targets
✓ energy efficiency and resilience

Living Labs

University of Birmingham and Centre for Sustainable Road Freight (Heriot-Watt University) has commenced a programme in India with
• States pf Haryana and Punjab
• NCCD (GOI taskforce on cold chain
• Shakti Foundation
• research and industrial partners

➢ first to last mile
➢ transport as well as storage
➢ zero emission / energy efficient
➢ fit for market,
➢ fit for finance

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Appendix

Example: Novel technology and integrated Business Model innovation – Cold Storage

**Issue:** Small scale farmers have difficulty accessing cold storage facilities for pre-cooling of produce before shipment. Many of the incumbent solutions are too large and capital intensive to be feasible or run off diesel. Novel smaller village off-grid/solar thermal scale solutions are being developed with novel business models whereby the increased value in the product can create business case for service provision.

India

Nigeria
Appendix

Liquid Air - a novel energy vector

We need to store renewable / waste energy to use on demand in grid or transport applications.

Liquid air is about storing cold and power:

- Mature industry
- Rapid filling of liquids through pressure and pumped systems
- Distribution is through pipeline or road tanker

Transport Refrigeration

- Zero emissions at the point of use;
- Lower CO₂ footprint;
- Better functionality
- Cost competitive to diesel

Back-up power and energy services

- Provision of zero emission cooling and back-up power and/or power-on-demand
- Aimed at refrigerated buildings, data centres and supermarkets (sub 1MW market)

Cryogenic Engine
Tank of Cold

Liquid air brings flexibility as it can find uses in multiple static and transport cooling applications.